40 Shattuck Road | Suite 110
Andover, Massachusetts 01810
www.woodardcurran.com

T 800.426.4262
T 978.557.8150
F 978.557.7948

March 29, 2023

Ms. Jennifer Miller
Conservation Director
Town of Westborough
Town Hall
34 West Main Street
Westborough, MA 01581

Re: Westborough, MA – Chauncy Lake Water Quality Evaluation

Dear Ms. Miller:

Woodard & Curran, Inc. in conjunction with our subconsultant, Aquatic Restoration Consulting, LLC performed in lake water quality monitoring and sediment sampling over the 2022 growing season as Phase 1 of Chauncy Lake improvement planning. This initial phase of work was focused on evaluating internal lake water quality conditions to support future development of management strategies.

The water quality assessment included six rounds of water sampling and testing, at two depths in a single location. Samples were analyzed for key parameters including total phosphorus (TP), dissolved phosphorus (DP), total Kjeldahl nitrogen (TKN), nitrate/nitrite nitrogen, and ammonia. A depth profile of temperature, dissolved oxygen, pH, conductivity, and turbidity was also recorded during each sampling event to assess the extent of low-oxygen at the sediment-water interface. Surface water samples were also collected and analyzed for phytoplankton and zooplankton.

The lake bottom sediment was also assessed to delineate muck deposits and assess the potential for significant phosphorus cycling. Three sediment samples were collected and analyzed to assess the quantity of available phosphorus in surficial lake sediment. Samples were analyzed for percent solids/percent water, total organic carbon, TP, loosely bound P, iron bound P (Fe-P), aluminum bound P (Al-P), calcium bound P (Ca-P), biogenic P and organic P. This data allows for calculation of the potential mass P that could be released during low dissolved oxygen conditions, allowing for estimation of P concentrations due to sediment P release.

The 2022 analysis found that in-lake phosphorus is enough to support algal blooms. Water samples show that phosphorus concentrations are well above that known to support algal blooms. TP was found to be higher in the spring, which could indicate high pollutant loading from runoff, though it is likely a combination of this and P accumulation which has not been flushed from the prior summer. 67% of the phosphorus in Chauncy Lake is dissolved phosphorus, which is readily available for algal uptake. Anoxic conditions below 12 feet were observed, which supports the release of P from sediments, increasing the availability of nutrients for algal blooms. Lake Chauncy sediments contain moderate concentrations of P.

This initial phase of water quality monitoring and sediment evaluation provided information relative to the internal water quality conditions of the lake. In order to develop a lake and watershed management plan, both internal and external sources need to be evaluated. Internal and external sources would be managed in different ways; therefore, it is important to understand both the internal and external sources of nutrient to support cost effective management strategies.

Recommendations for the next phase of evaluation include the following:

- Additional assessment of watershed contributions to determine the proportion of total phosphorus load attributed to internal loading.
- A watershed and groundwater input assessment, estimation through simplistic modeling to update previous data from the 1985 Whitman and Howard study.
- Continuation of seasonal water quality monitoring program, for at least the 2023 season, is also recommended to collect additional data on key parameters for use in assessing management strategies.
- Collaboration on goals and strategies for the development of a management approach.

Additionally, it is recommended that on-going monitoring and treatment of plant growth be continued.

After you have had an opportunity to review the Lake Chauncy water quality evaluation report, we would like to schedule a meeting to review the results and recommendations for the next phase of study; we will contact you to schedule a convenient day. In the meantime, please feel free to call me at (781) 619-3289 if you have any questions or if we can provide any additional information.

We look forward to continuing to support the Town with this important on-going project.

Sincerely,

WOODARD & CURRAN

Stephanie Kaiser

Stephanie Kaiser, P.E.
Project Manager

Enclosure

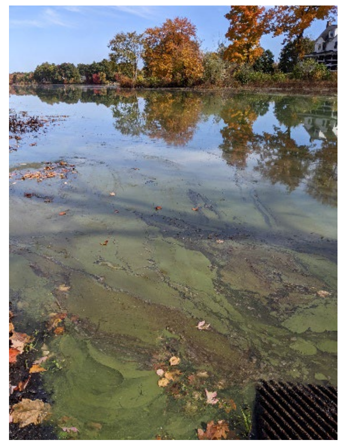
cc: Carol Harris, Zack Henderson; Woodard & Curran, Inc.
Wendy Gendron; ARC, LLC

PN: 0233706.00

Report For:

Woodard & Curran

Lake Chauncy
2022 Water Quality Monitoring and Sediment Evaluation



ARC Aquatic Restoration Consulting, LLC

Prepared by:
Aquatic Restoration Consulting, LLC
18 Sunset Drive
Ashburnham, MA 01430

March 2023

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Introduction

Lake Chauncy is a 175-acre[1] freshwater lake located in Westborough, Massachusetts. Maximum depth in Lake Chauncy is 21 feet (Figure 1); the average depth is 12.2 feet. It has a relatively small watershed of 815 acres compared to the lake area (Figure 2). The watershed is primarily in the Town of Westborough, but a small portion (2%) is located within Northborough. Approximately 53% of the watershed area is Town or State owned. About 12% of the watershed is residential land use and 14% is commercial and industrial (Table 1). There are several stormwater drainage conduits that drain directly to the lake, carrying pollutants from impervious areas to the lake with minimal attenuation. Much of the western portion of the watershed is mapped as Natural Heritage Endangered Species Program (NHESP) Priority Habitat based on state listed protected species under the Massachusetts Endangered Species Act (Figure 3). There are also several certified and potential vernal pools in the watershed.

Lake Chauncy is a popular recreational area to fish, swim and hike the surrounding State Park and Town Wildlife Management Area. The lake is also used during the winter months for ice fishing, ice boating, ice skating and snowmobiling. The Town maintains the beach at the southeastern side of the lake and there is a public boat launch at the southern end of the lake maintained by the State. The lake itself has suffered from excessive algal and aquatic plant growth (including several non-native invasive species) and decreased water clarity. The Town has employed several management measures to control plant and algae biomass. Lake Chauncy is listed on Draft Massachusetts Integrated List of Waters for the Clean Water Act 2022 Reporting Cycle[2] as impaired due to Eurasian water milfoil (*Myriophyllum spicatum*) and harmful algal blooms.

Previous studies of Lake Chauncy include:

- 1971 Massachusetts Division of Water Pollution Control – Baseline Water Quality
- 1977 Interdisciplinary Environmental Planning (IEP)– Reclamation Study
- 1979 IEP – development of a long-term reclamation program
- 1986 – Whitman & Howard, Inc – Diagnostic/Feasibility Study
- Several annual reports detailing macrophyte and algae management implementation strategies (e.g., hydroraking, herbicides, algaecides, etc.).

These water quality studies concluded that the lake is artificially enriched due to watershed development and land use practices. Excessive nitrogen and phosphorus are to blame for decreased aquatic habitat, impaired recreational enjoyment, and poor aesthetics of the lake. Whitman & Howard found that in-lake total phosphorus (TP) averaged 0.05 milligrams per liter (mg/L) from October 1984 through September 1985, well above the 1986 Environmental Protection Agency (EPA) recommended “Gold Book” concentrations for lakes (0.025 mg/L)[3]. The report also documents low dissolved oxygen (DO) in the hypolimnion at and below 13 feet (4 meters) but the internal load was not estimated in their report.

[1] Ranges between 173 and 182 acres depending on source

[2] Integrated list of waters available at www.mass.gov/doc/draft-massachusetts-integrated-list-of-waters-2022-reporting-cycle/download

[3] 1986 EPA Quality Criteria for Water (Gold Book). www.epa.gov/sites/production/files/2018-10/documents/quality-criteria-water-1986.pdf

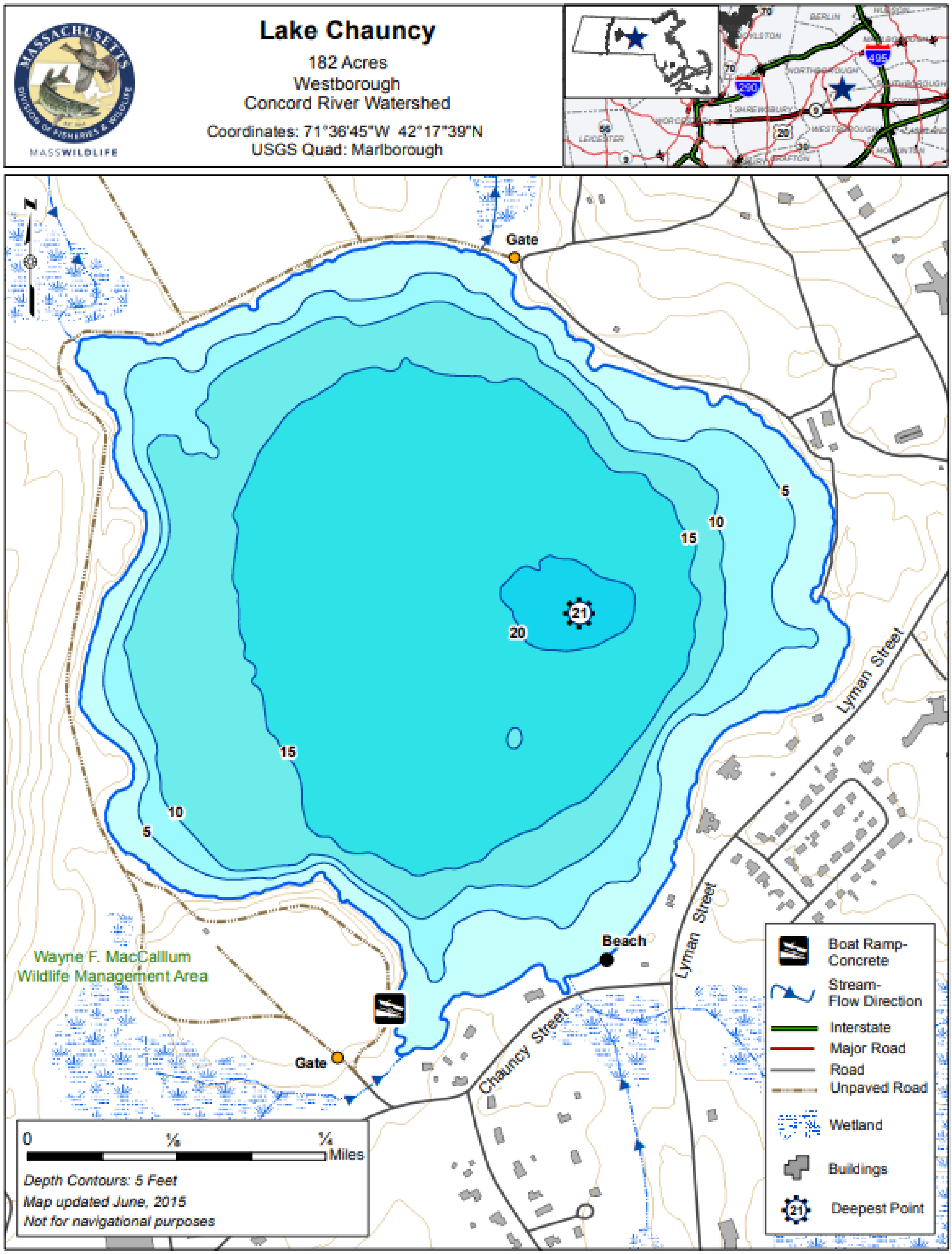


Figure 1. Lake Chauncy Bathymetry[4]

[4] MassWildlife available at: https://www.mass.gov/files/documents/2016/08/uj/dfwchau.pdf

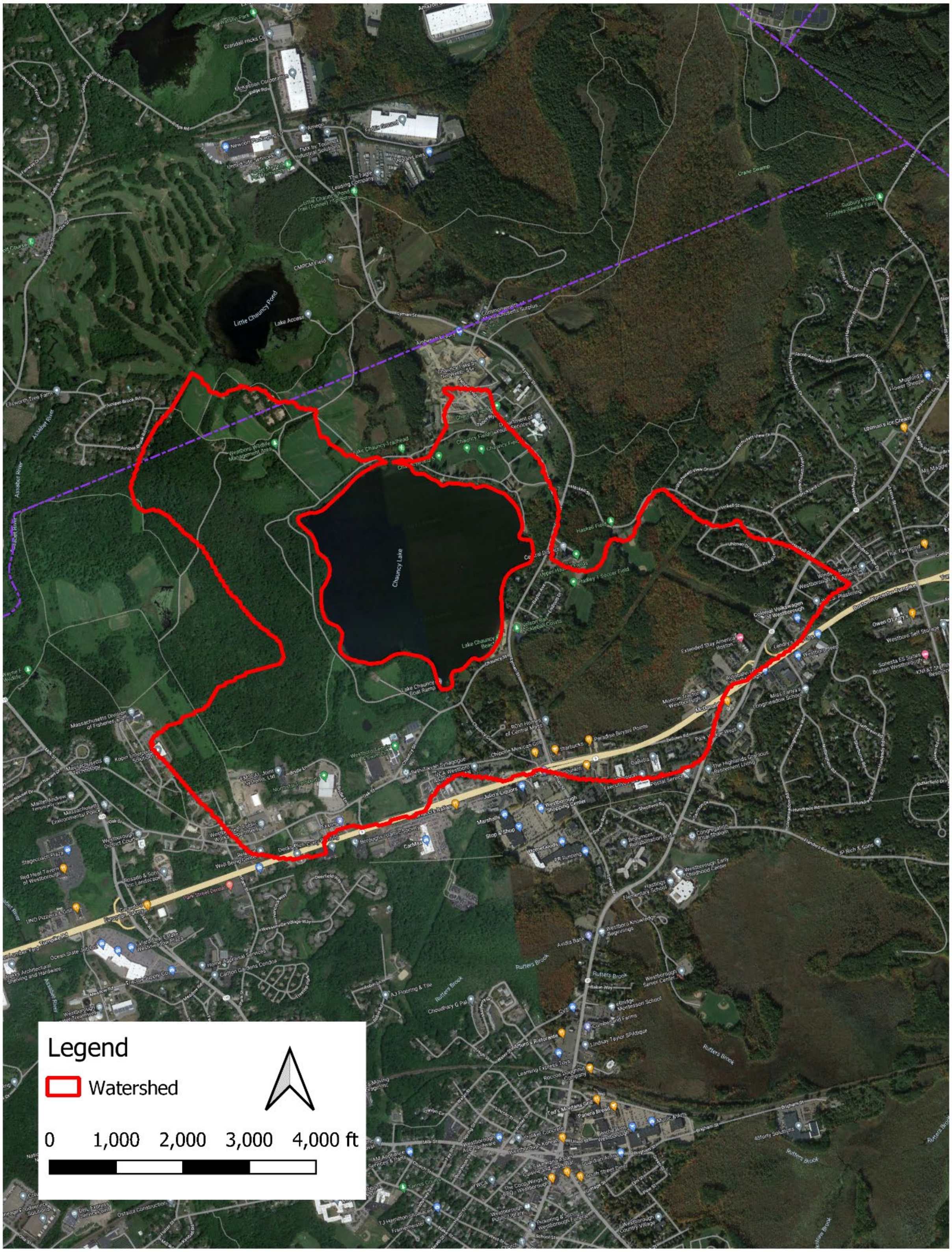


Figure 2. Lake Chauncy and Watershed.

Table 1. Watershed Land Use

Land Use	Area (acre)	% Total Area
Commercial	80.1	9.8
Industrial	23.9	2.9
Mixed use, other	4.9	0.6
Mixed use, primarily commercial	5.9	0.7
Mixed use, primarily residential	0.8	0.1
Open land	134.8	16.5
Residential - multi-family	9.9	1.2
Residential - other	1.6	0.2
Residential - single family	79.0	9.7
Right-of-way	43.4	5.3
Tax exempt	430.9	52.9
Unknown	0.1	0.0
Total	**815.2**	

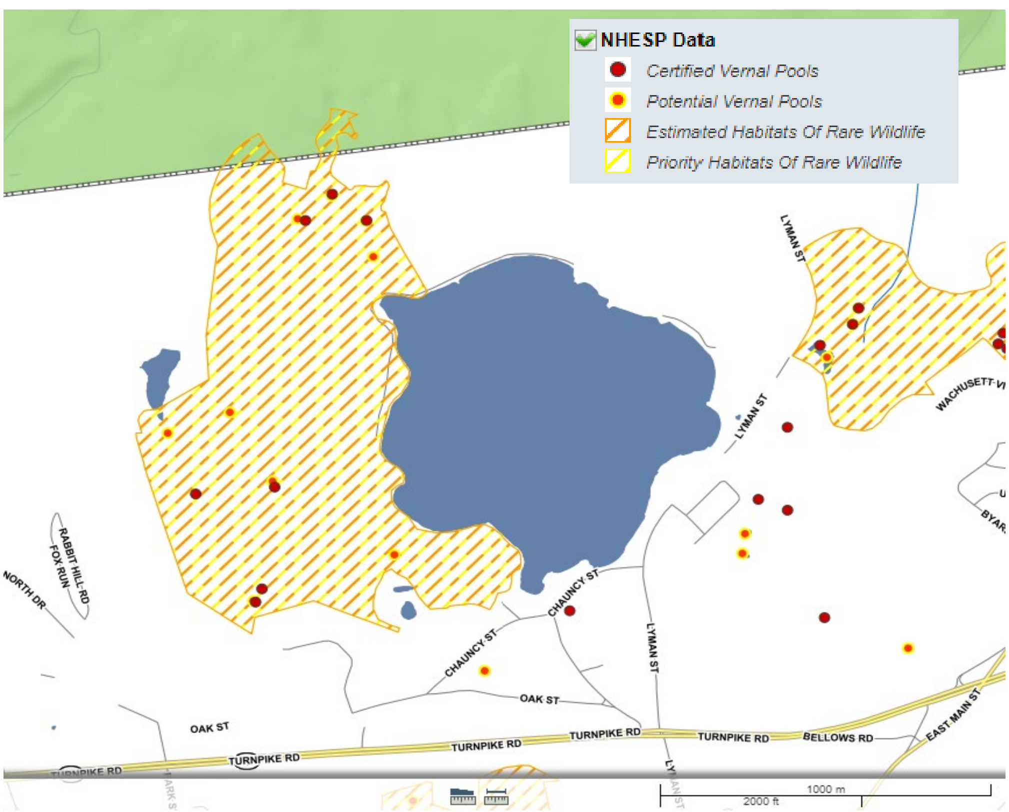


Figure 3. NHESP Habitat Mapping[5]

[5] Online mapping available at: https://www.mapsonline.net/westboroughma/

Given that the last known comprehensive water quality survey is over 35 years old, the Town of Westborough desired to acquire recent data to explore the feasibility of management measures to improve conditions. Aquatic Restoration Consulting, LLC (ARC) was retained by Woodard & Curran to assess the existing in-lake conditions, measure phosphorus concentrations in the sediment and evaluate internal phosphorus loading potential. ARC performed monthly water quality sampling from April through October in 2022 and assessed lake sediment samples in areas suspected to release phosphorus during the summer. Results of this effort are presented in this report.

It should be noted that while this assessment was comprehensive in terms of in-lake sampling, it does not address the watershed surface and groundwater nutrient loading, which, according to the Whitman & Howard Report, is enough to result in eutrophic conditions absent internal loading from the sediments.

Approach and Methods

ARC performed field surveys monthly from April through October 2022. Scientists evaluated water quality at one location (Figure 4) at two depths, surface (epilimnion) and bottom (hypolimnion). In-lake sampling included depth profile in-situ measurements of temperature, DO, pH, conductivity, and turbidity. Scientists collected grab water samples at the surface and near the sediment-water interface. A Massachusetts State Certified analytical laboratory analyzed samples for several forms of nutrients: TP, dissolved phosphorus (DP), nitrite and nitrate nitrogen (NO_2+NO_3), total Kjeldahl nitrogen (TKN), and ammonium nitrogen (NH_3-N). All samples were placed in laboratory provided pre-preserved bottles and stored on ice. Samples for phytoplankton (algae) and zooplankton (microscopic animals) were collected monthly in from June through October. The phytoplankton samples were whole water grabs from approximately 0.5 feet below the water surface. A scientist used a 30-meter plankton tow net with 80µ mesh to collect zooplankton samples for analysis. Plankton samples were preserved with glutaraldehyde and delivered to Dr. Kenneth Wagner, from Water Resource Services, who performed quantitative analyses using a phased contrast microscope at 100-400X magnification.

ARC collected surficial sediment at three locations in Lake Chauncy (Figure 4), covering the area expected to be exposed to anoxia. One duplicate sample was analyzed for quality control and to quantify variability. Samples were tested for TP, loosely bound P, iron-bound P (Fe-P), aluminum bound P (Al-P), biogenic P, calcium bound P (Ca-P), organic P, and percent solids. This phosphorus fraction allows for calculation of available Fe-P and its relation to TP and other key sediment features. ARC collected samples using an Ekman dredge. The scientist removed the upper 10 cm of sediment, mixed sediment in a stainless-steel bowl, and placed sediment into glass amber jars. Samples were shipped to a specialized laboratory for analysis. The range of plausible mass release from sediment was calculated based on the range of percent release known from other lakes and daily release rates expected as a function of measured Fe-P and area of sediment exposed to anoxia.

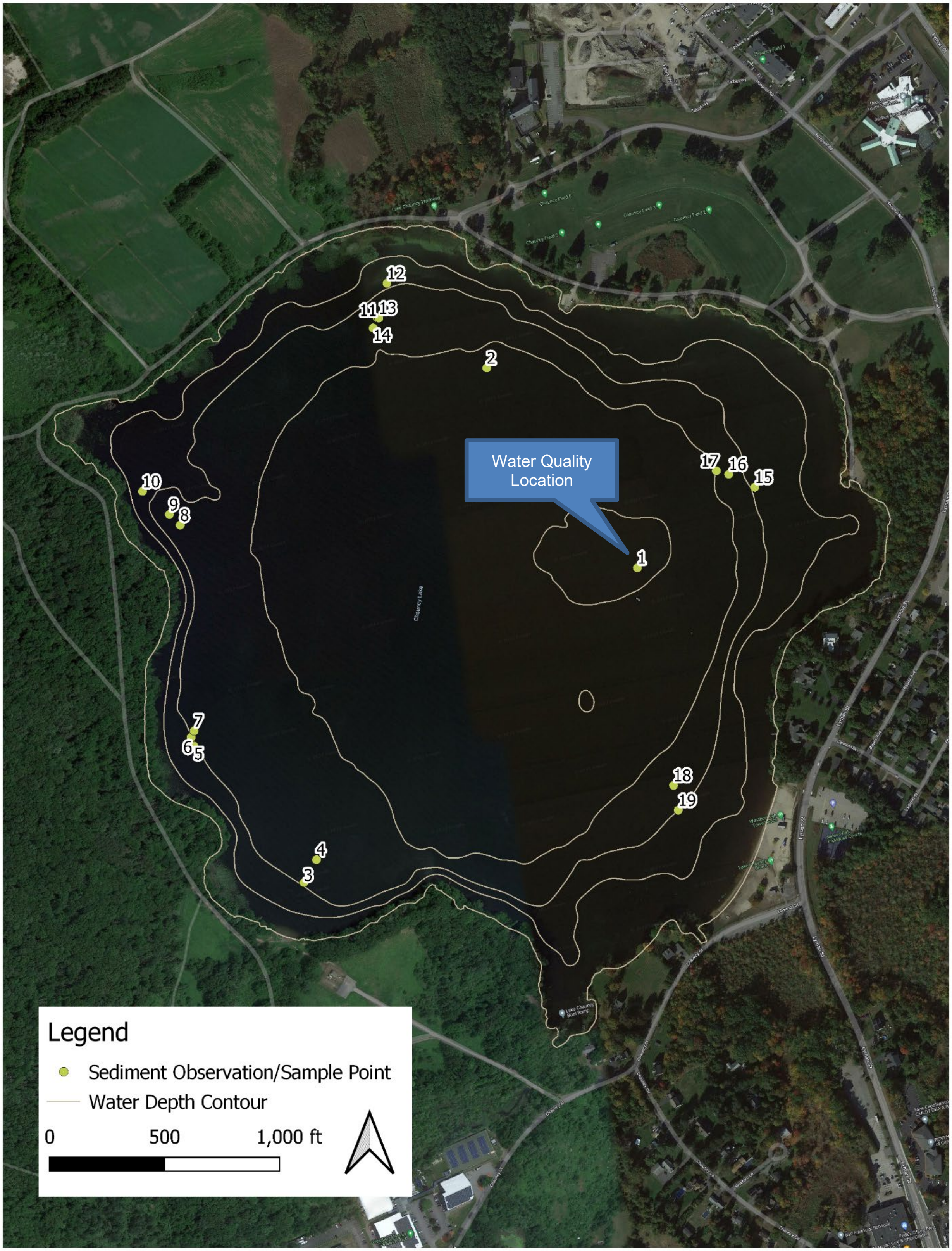


Figure 4. Water & Sediment Locations

Assessment

Water Quality

In-situ measurements

Lake Chauncy began to thermally stratify in May with moderate to strong stratification apparent through August. The lake was completely mixed by September 28, 2022. The thermocline (boundary between upper, warmer layer and lower, colder, layer) was present at approximately 8 feet (ft) in June, 13 ft in July and 17 ft in August (Figure 5). This variability suggests that stratification is not strong and could be destabilized even in the summer months. Epilimnetic (upper water layer during stratification) oxygen was above the Massachusetts State Water Quality Standards (WQS) for Class B warm water fisheries [5.0 milligrams per liter (mg/L)] during all sampling events. Oxygen was depressed starting in May at 16 ft, and anoxic conditions (defined as concentrations less than 2.0 mg/L) were present at water depths greater than 16 ft during June, 13 ft in July and 11 ft in August 2022. DO deficit in 1985 was comparable to 2022. Whitman & Howard recorded anoxia as shallow as 13 ft, with onset occurring mid/late June at about 16 ft. In the absence of oxygen, certain undesirable chemical compounds will accumulate in the bottom water layer, most notably dissolved and particulate phosphorus, iron and manganese, ammonia, and possibly hydrogen sulfide. These conditions are ideal for sediment phosphorus release with potential to fuel harmful algal blooms.

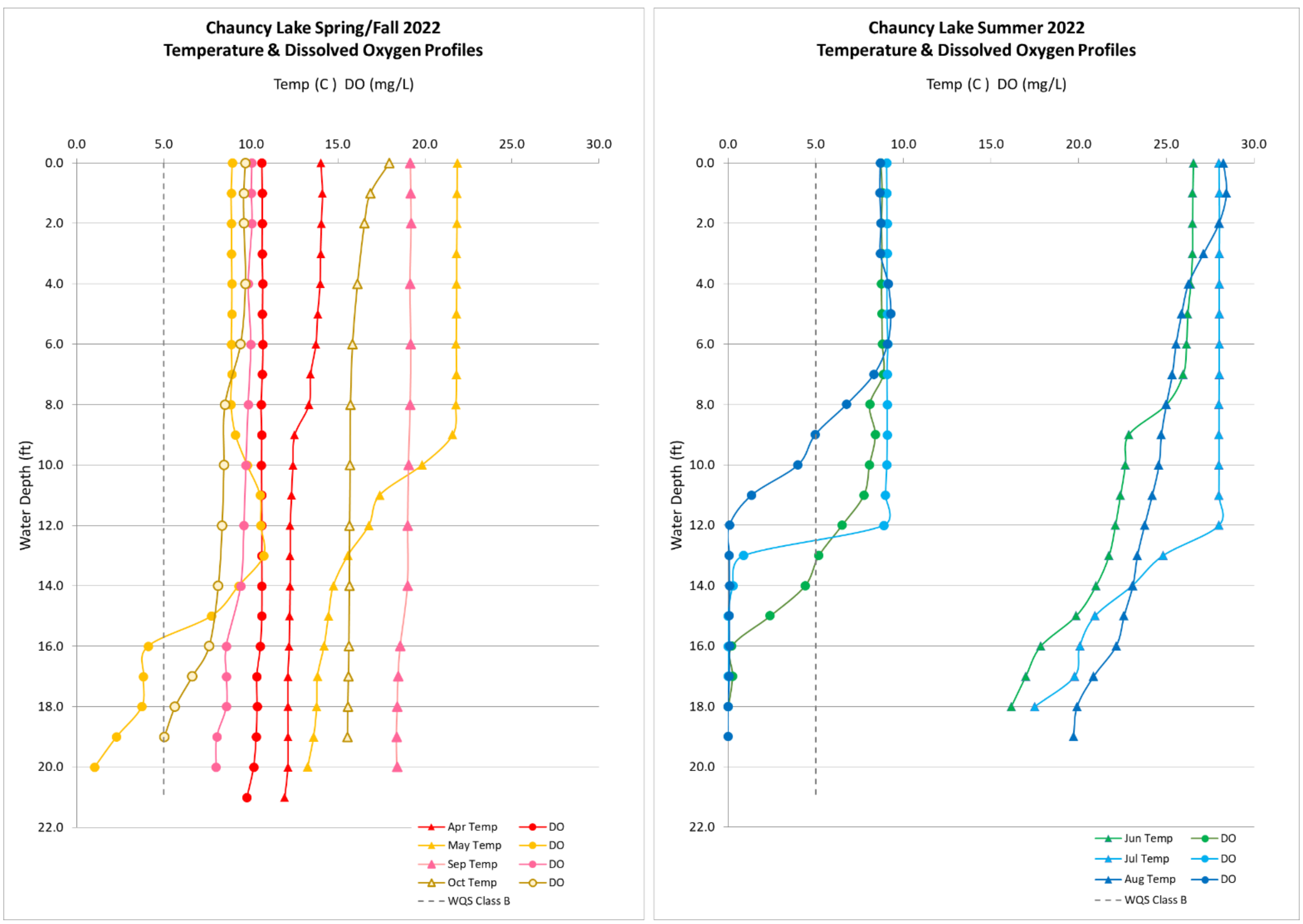


Figure 5. Lake Chauncy Temperature and Dissolved Oxygen Profiles

Like temperature and DO, water depth profiles for pH, specific conductivity and turbidity were recorded throughout the spring, summer and fall season. These data are provided in Table 2. pH is a measure of hydrogen ion concentration and provides an indication of whether the water is acidic [pH <7 standard units (SU)] or basic (pH>7 SU)]. Values for Lake Chauncy ranged between 6.2 and 9.2 SU. The WQS for pH is a range of 6.5 to 8.3 SU. Low pH was generally found in the deep area whereas the higher pH was recorded either mid-depth or near the surface. The difference in pH is likely due to photosynthesis, when algae and rooted plants in the upper water remove carbon dioxide from the water raising pH; the opposite occurs during plant respiration. This is why lake pH is typically at the lowest level just before dawn and highest in the afternoon. Low pH near the bottom is typically a result of decomposition of organic matter. These influences can vary over time within a season and among years, but these data suggest that Lake Chauncy has high primary productivity causing large variation in pH.

Conductivity measures the quantity of dissolved solids in water. It is a rough indicator of overall fertility, or potential productivity. Specific conductivity is the measure of conductance corrected for temperature at 25°C. This allows for comparisons when temperatures vary. Specific conductance in Lake Chauncy ranged from 347 to 631 microsiemens per centimeter (µS/cm) and was uniform throughout the water column but increased from spring into the summer (Table 2). Average conductivity was 496 µS/cm and considered high. Values below 100 µS/cm are considered low. Values above this level usually indicate human disturbance from road salts, wastewater, and stormwater runoff from developed and agricultural areas. Values above 500 µS/cm are excessive. Conductivity in 2022 was over twice that of in 1984-1985 (199 µS/cm) indicating a drastic increase with time.

Turbidity measures suspended solids in the water column, including algae and sediment, and other light scattering (e.g., bubbles) or adsorption material (e.g., dissolved organic matter). Turbidity values in Lake Chauncy were variable and ranged from 0 to 304 Nephelometric Turbidity Units (NTU) in 2022. Average turbidity in 2022 was 31.1 NTU. Turbidity was not measured in 1984-1985, but total suspended solids (TSS) was included. While these are two separate variables, the 1984-1985 TSS results indicating that Lake Chauncy had a moderate amount of suspended matter in the water column and would likely cause increased water turbidity.

Another visual measure of water clarity is Secchi disk transparency (SDT). SDT in Lake Chauncy during 2022 ranged between 1.3 and 4.7 meters (4.4 and 15.4 feet; Figure 6). The months of April and May were the clearest. Minimum and maximum clarity during the Whitman & Howard investigation was 2.6 and 10.5 feet, respectively.

Table 2. Lake Chauncy In-Situ Water Quality Results

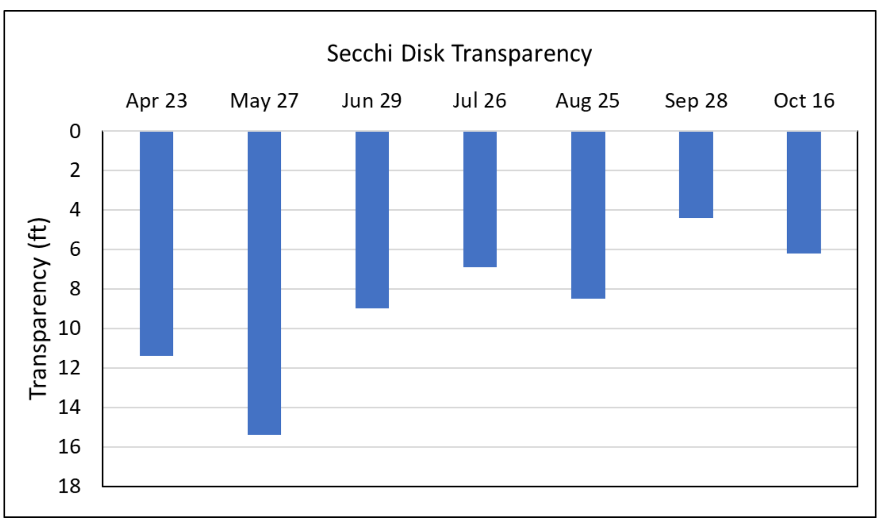
4/23/2022						5/27/2022						6/29/2022					
Depth (ft)	Temp (°C)	DO (mg/L)	pH (SU)	Spec Cond (us/cm)	Turbidity (NTU)	Depth (ft)	Temp (°C)	DO (mg/L)	pH (SU)	Spec Cond (us/cm)	Turbidity (NTU)	Depth (ft)	Temp (°C)	DO (mg/L)	pH (SU)	Spec Cond (us/cm)	Turbidity (NTU)
0.0	14.0	10.6	7.3	348.7	0.0	0.0	21.9	8.9	7.4	366.4	0.0	0.0	26.5	8.7	7.6	538.6	0.0
1.0	14.1	10.7	7.3	348.6	0.0	1.0	21.9	8.9		366.3	0.0	1.0	26.5	8.8	7.6	539.0	0.0
2.0	14.1	10.7	7.8	349.0	0.0	2.0	21.8	8.9		366.2	0.0	2.0	26.5	8.8	7.5	538.4	0.0
3.0	14.0	10.6	8.4	348.3	0.0	3.0	21.8	8.9		366.2	0.0	3.0	26.5	8.8	7.4	538.2	0.0
4.0	14.0	10.7	8.3	348.4	0.0	4.0	21.8	8.9		366.4	0.0	4.0	26.4	8.8	7.4	538.5	0.0
5.0	13.8	10.7	8.3	348.1	0.0	5.0	21.8	8.9		366.1	0.0	5.0	26.2	8.8	7.3	538.9	0.0
6.0	13.7	10.7	8.2	348.2	0.0	6.0	21.8	8.9		366.1	0.0	6.0	26.1	8.8	7.2	537.8	0.0
7.0	13.4	10.7	8.2	348.9	0.0	7.0	21.8	8.9		366.2	0.0	7.0	26.0	8.9	7.1	537.5	0.0
8.0	13.3	10.6	8.1	348.0	0.0	8.0	21.8	8.9		366.2	0.0	8.0	25.0	8.1	6.8	532.6	0.0
9.0	12.5	10.6	8.2	347.4	0.0	9.0	21.6	9.1		366.4	0.0	9.0	22.9	8.4	6.7	532.4	0.0
10.0	12.4	10.6	8.0	347.6	0.0	10.0	19.8	9.8		364.0	0.0	10.0	22.7	8.1	6.6	531.8	0.0
11.0	12.3	10.6	8.2	347.8	0.0	11.0	17.4	10.5		356.7	0.0	11.0	22.4	7.8	6.7	530.8	0.0
12.0	12.3	10.6	8.3	347.2	0.0	12.0	16.8	10.6		355.0	0.0	12.0	22.1	6.5	7.2	530.5	0.0
13.0	12.3	10.6	8.3	347.5	0.0	13.0	15.6	10.7		355.0	0.0	13.0	21.7	5.2	7.3	529.8	0.0
14.0	12.3	10.6	8.2	347.1	0.0	14.0	14.7	9.3		354.9	0.0	14.0	21.0	4.4	7.5	528.7	0.0
15.0	12.2	10.6	8.2	347.1	0.0	15.0	14.5	7.7		355.2	0.0	15.0	19.9	2.4	7.0	529.0	0.0
16.0	12.2	10.5	8.2	347.2	0.0	16.0	14.2	4.1		356.7	0.0	16.0	17.8	0.2	6.9	530.0	0.0
17.0	12.1	10.3	8.1	347.1	0.0	17.0	13.8	3.8		357.7	0.0	17.0	17.0	0.3	7.0	528.3	0.0
18.0	12.1	10.4	8.2	347.2	0.0	18.0	13.8	3.7		356.6	0.0	18.0	16.2	0.0	7.0	530.1	0.0
19.0	12.1	10.3	8.2	347.2	0.0	19.0	13.6	2.3		359.9	0.0	19.0					
20.0	12.1	10.2	8.2	347.2	0.0	20.0	13.3	1.0	7.2	360.1	0.0	20.0					

Table 2 (continued) Lake Chauncy In-Situ Water Quality Results

7/26/2022						8/25/2022						9/28/2022					
Depth (ft)	Temp (°C)	DO (mg/L)	pH (SU)	Spec Cond (us/cm)	Turbidity (NTU)	Depth (ft)	Temp (°C)	DO (mg/L)	pH (SU)	Spec Cond (us/cm)	Turbidity (NTU)	Depth (ft)	Temp (°C)	DO (mg/L)	pH (SU)	Spec Cond (us/cm)	Turbidity (NTU)
0.0	28.0	9.0	8.8	559.8	14.6	0.0	28.3	8.7	8.5	587.7	83.2	0.0	19.2	10.1	7.8	585.0	0.0
1.0	28.0	9.1	9.2	559.3	14.5	1.0	28.4	8.7	8.5	589.8	66.6	1.0	19.2	10.0	7.8	584.9	0.6
2.0	28.0	9.1	8.9	559.1	21.6	2.0	28.0	8.7	8.3	588.1	45.5	2.0	19.2	10.1	8.5	585.1	4.8
3.0	28.0	9.1	8.8	559.1	18.2	3.0	27.1	8.7	8.1	584.3	76.7	3.0					
4.0	28.0	9.1	8.9	559.7	16.8	4.0	26.3	9.1	8.0	584.6	78.5	4.0	19.2	9.9	7.1	585.7	4.9
5.0	28.0	9.1	8.9	559.5	15.5	5.0	25.9	9.3	8.0	584.1	119.7	5.0					
6.0	28.0	9.1	9.0	559.1	14.5	6.0	25.5	9.1	7.9	584.4	125.0	6.0	19.2	10.0	7.1	584.9	6.6
7.0	28.0	9.1	9.0	559.6	13.7	7.0	25.3	8.3	7.4	584.2	137.6	7.0					
8.0	28.0	9.1	9.0	559.2	14.3	8.0	25.0	6.8	6.5	583.4	144.6	8.0	19.2	9.8	7.0	584.8	7.3
9.0	28.0	9.1	8.9	559.4	14.2	9.0	24.7	5.0	6.8	582.9	155.5	9.0					
10.0	28.0	9.1	8.9	559.4	14.2	10.0	24.6	4.0	6.7	582.7	161.6	10.0	19.1	9.7	6.9	584.5	13.4
11.0	28.0	9.0	8.9	559.8	14.8	11.0	24.2	1.4	6.6	581.9	170.4	11.0					
12.0	28.0	8.9	8.8	559.1	14.4	12.0	23.8	0.1	6.7	580.5	178.7	12.0	19.0	9.6	6.9	584.4	9.5
13.0	24.8	0.9	8.0	551.7	13.7	13.0	23.3	0.1	6.8	587.2	205.5	13.0					
14.0	23.0	0.3	7.7	543.3	14.5	14.0	23.1	0.1	6.9	589.2	227.1	14.0	19.0	9.4	6.7	584.4	8.1
15.0	20.9	0.0	7.1	546.3	18.9	15.0	22.6	0.1	6.9	592.1	254.4	15.0					
16.0	20.1	0.0	7.0	546.4	23.4	16.0	22.1	0.1	6.9	602.1	280.5	16.0	18.6	8.6	6.8	584.0	14.9
17.0	19.8	0.0	6.9	546.5	25.3	17.0	20.9	0.1	6.8	610.3	288.9	17.0	18.5	8.6	6.7	584.3	9.6
18.0	17.5	0.0	7.4	577.8	25.3	18.0	19.9	0.0	6.7	631.6	304.1	18.0	18.4	8.6	6.4	584.3	0.0
19.0						19.0	19.7	0.0	6.7	631.7	296.1	19.0	18.4	8.0	6.3	584.3	0.0
20.0						20.0						20.0	18.4	8.0	6.4	584.1	0.0

Table 2 (continued) Lake Chauncy In-Situ Water Quality Results

10/16/2022					
Depth (ft)	Temp (°C)	DO (mg/L)	pH (SU)	Spec Cond (us/cm)	Turbidity (NTU)
0.0	17.9	9.7	7.5	579.5	25.0
1.0	16.9	9.6	7.6	577.9	24.9
2.0	16.5	9.6	7.4	577.2	24.0
3.0					
4.0	16.1	9.7	7.2	578.0	22.9
5.0					
6.0	15.8	9.4	7.1	577.0	21.5
7.0					
8.0	15.7	8.5	6.9	576.8	20.3
9.0					
10.0	15.7	8.5	6.9	576.8	18.7
11.0					
12.0	15.7	8.4	6.9	576.7	14.3
13.0					
14.0	15.7	8.1	6.9	576.8	7.8
15.0					
16.0	15.6	7.6	6.8	577.1	0.6
17.0	15.6	6.6	6.7	581.0	0.0
18.0	15.6	5.6	6.7	583.8	0.0
19.0	15.6	5.0	6.2	589.9	0.0
20.0					



Date	SDT (m)	SDT (ft)
Apr 23	3.5	11.4
May 27	4.7	15.4
Jun 29	2.7	9.0
Jul 26	2.1	6.9
Aug 25	2.6	8.5
Sep 28	1.3	4.4
Oct 16	1.9	6.2

Figure 6. Lake Chauncy Secchi Disk Transparency 2022.

Nutrients

Phosphorus is usually the nutrient limiting freshwater photosynthetic organisms, including algae. Total phosphorus (TP) includes all forms of phosphorus in the water column, from readily absorbable dissolved orthophosphates to refractory particulate phosphorus. TP, along with other variables, is often used as a measure of a lake trophic state. Surface TP concentrations below 0.010 mg/l are usually associated with clear water and lack of appreciable phytoplankton scums. TP at or above 0.025 mg/L can support algal blooms, although in some lakes, concentrations as low as 0.020 mg/L are supportive of recurring blooms.

Grab water samples for Lake Chauncy suggest that phosphorus concentrations are variable and range from less than detection (<0.01 mg/L) to 0.142 mg/L (Table 3). Average surface water concentration was 0.033 mg/L, well above the concentration known to support frequent algal blooms. TP was greater in the spring, which could indicate high pollutant loading from runoff or the accumulation of phosphorus from the prior summer that has not been flushed. It is most likely a combination of both. Additional monitoring data will assist with identifying the potential source of high spring TP concentrations. Bottom water TP concentrations were generally higher and are typical of stratified lakes experiencing eutrophication.

Much of the phosphorus in Lake Chauncy (67%) is in the dissolved form and readily available for algal uptake. Dissolved phosphorus (DP) refers to the soluble portion of TP (inorganic and organic). DP is more readily available to aquatic organisms than particulate phosphorus, and may be a more accurate variable for predicting water quality than TP. However, analytical method consistency over the years has led to most relationships being based on TP. Because of the lack of reference concentration values for DP, the 0.010-0.025 mg/L TP reference values are used here, but DP may be cycled so rapidly suggesting that the presence of measurable DP is a negative sign.

Nitrogen is a nutrient that also may be limiting for aquatic organisms such as algae and plants. Nitrogen exists in lakes in many forms. The most important forms of readily absorbable nitrogen are nitrate (NO_{3-}) and ammonium (NH_{4+}) (Wetzel 1983)[6]. Nitrite is also adsorbable but is rarely found in quantities above detection levels in lakes because it is rapidly converted to nitrate during the nitrification process. Limnologists typically measure the both nitrite and nitrate together (NO_2^- + NO_{3-}) Both forms are unlikely to cause water quality problems such as algal blooms at concentrations below 0.3 mg/L, but problems may occur at concentrations above 1 mg/L. Nitrite and nitrate were below the detection limit (0.02 mg/L) in all but one sample (bottom sampling in July). Ammonia was elevated in most samples, including at the surface (Table 3), but generally does not exceed WQS for the maximum concentration for discrete samples. Surface water ammonia in 2022 (0.44 mg/L) was higher than in 1984-1985 (0.11 mg/L). Increased pH favors the more toxic form of ammonia in waterbodies, and unfortunately Lake Chauncy experiences high pH. The WQS for ammonia depends on both pH and water temperature. Only one surface sample exceeded the acute Criterion Maximum Concentration WQS. The surface ammonia concentration on August 25, 2022 was 0.78 mg/L and occurred when pH was 8.5 SU and at a temperature of 28°C. The WQS under these conditions is 0.77 mg/L. However, all other surface samples were below their calculated standard based on temperature and pH. Ammonia can cause morbidity and mortality in fish and other aquatic organisms. Ammonia is most often derived from wastes (stormwater and sewage), fertilizers and natural sources and processes (atmosphere, decomposition).

[6] Wetzel R. G., 1983. *Limnology*, 2nd edition. Saunders College Publishing, Philadelphia, PA.

Table 3. Lake Chauncy Nutrients 2022.

	23-Apr-2022		27-May-2022		29-Jun-2022		26-Jul-2022		25-Aug-2022		28-Sep-2022		16-Oct-2022	
	Surface	Bottom	Surface	Bottom	Surface	Bottom	Surface	Bottom	Surface	Bottom	Surface	Bottom	Surface	Bottom
	CL-1S	CL-1B	CL-1S	CL-1B	CL-1S	CL-1B	CL-1S	CL-1B	CL-1S	CL-1B	CL-1S	CL-1B	CL-1S	CL-1B
TP	**0.142**	**0.054**	0.022	0.022	<0.010	0.011	<0.010	0.012	0.017	0.023	0.015	0.013	**0.027**	<0.020
DP	**0.032**	**0.036**	0.015	0.018	<0.010	<0.010	<0.010	<0.010	0.013	0.016	0.011	<0.010	0.020	<0.020
TKN	0.62	0.46	0.53	0.80	1.81	0.87	0.80	1.17	1.86	1.58	0.84	0.74	0.56	0.50
N02+N03	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.024	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
NH3-N	0.35	0.23	0.32	0.14	0.26	0.21	0.15	0.28	0.78	0.15	0.14	0.13	1.09	0.51
Total N	0.97	0.69	0.85	0.94	2.07	1.08	0.95	1.45	2.64	1.73	0.98	0.87	1.65	1.01
	Phosphorus above 0.025 mg/L; enough to support algal bloom													

Total Kjeldahl nitrogen (TKN) is a measure of ammonium-N and organic nitrogen forms present in the water column. Low (<0.5 mg/L) TKN concentrations are usually indicative of desirable water quality, with problems such as algal blooms unlikely to occur. Concentrations higher than 2 mg/L are indicative of undesirable water quality, with a substantial transition range in between those thresholds. TKN values did exceed the 0.5 mg/L threshold, but no samples exceeded 2 mg/L. TKN was generally higher in the summer months than spring and fall. Average surface TKN was 1.00 mg/L, much higher than the 1984-1985 average of 0.23 mg/L.

Total nitrogen concentrations [(the sum of total Kjeldahl nitrogen (TKN) and nitrate+nitrite nitrogen)] less than 0.3 mg/L in lakes is considered low, values between 0.3 and 1.0 mg/L are moderate and values exceeding 1.0 mg/L are high. TN ranged from 0.69 mg/L to 2.64 mg/L. Average surface TN was 1.44 mg/L and is high. These elevated values are driven by both elevated TKN and ammonia; ammonia is often undetected in well oxygenated surface waters because it is oxidized by bacteria converting it to nitrate and nitrite. The presence of high ammonia suggests an imbalance in the system and possibly a high nitrogen load source.

While phosphorus usually determines phytoplankton biomass (quantity of suspended algae), the N:P (by weight) ratio often determines phytoplankton species composition. Generally, when nitrogen concentrations are low, blue-greens (Cyanophyta/cyanobacteria) are favored. Many species of cyanobacteria can fix atmospheric nitrogen and are more efficient at phosphorus uptake (Lee 1989)[7]. When N:P is higher than 15:1, green algae (Chlorophyta) are typically favored. When nutrient levels are high overall, nuisance cyanobacteria blooms are more likely to occur. N:P ratios in Lake Chauncy average 65:1. While this condition would favor green algae, there is an overabundance of both nutrients (nitrogen and phosphorus) to promote cyanobacteria. These conditions coupled with warm temperatures favor cyanobacteria. There is also a growing body of literature suggesting that the speciation of nitrogen also play a role in phytoplankton community structure and this maybe influencing the composition in Lake Chauncy.

[7] Lee R. E., 1989. *Phycology*, 2nd edition. Cambridge University Press, Cambridge, GB.

Plankton

Phytoplankton

Samples for phytoplankton and zooplankton were collected monthly during June through October in 2022. Analysis of phytoplankton (algae in the water column) suggests that the taxonomic division, Cyanophtya (cyanobacteria) make up the highest cell count of all samples (Figure 7). Five species of cyanobacteria were identified in the monthly samples: *Dolichospermum* was the most frequently identified (present in all five samples) with *Microcystis* the next most frequently identified in three of the five samples. Although cyanobacteria made up a large portion of the number of cells per mL during the summer, the numbers remained below the Massachusetts Department of Health threshold for posting contact recreation advisory of 70,000 cells/mL. These data are epilimnetic grab (whole water) samples and not samples of blooms. Wind-blown areas often contain concentrated numbers and may present a localized risk. There were obvious cyanobacteria localized blooms at Lake Chauncy in 2022, but these were not sampled by ARC.

Phytoplankton biomass was low (<1,000 µg/L) for all samples (Figure 8), which was a bit surprising based on lake appearance (green color), low SDT and the presence of concentrated cyanobacteria at the boat launch during the site visits. The mid-lake surface sample was likely well mixed, unlike the concentrated algae observed in shallow water. The phytoplankton community was more evenly represented by most forms in June. Cyanophyta and Bacillariophyta (diatoms) made up the bulk of the biomass in July and October. Pyrrhophyta (dinoflagellates) were more abundant in August and September than in other months. Overall, Cyanobacteria accounted for 22%-48% of the biomass each month.

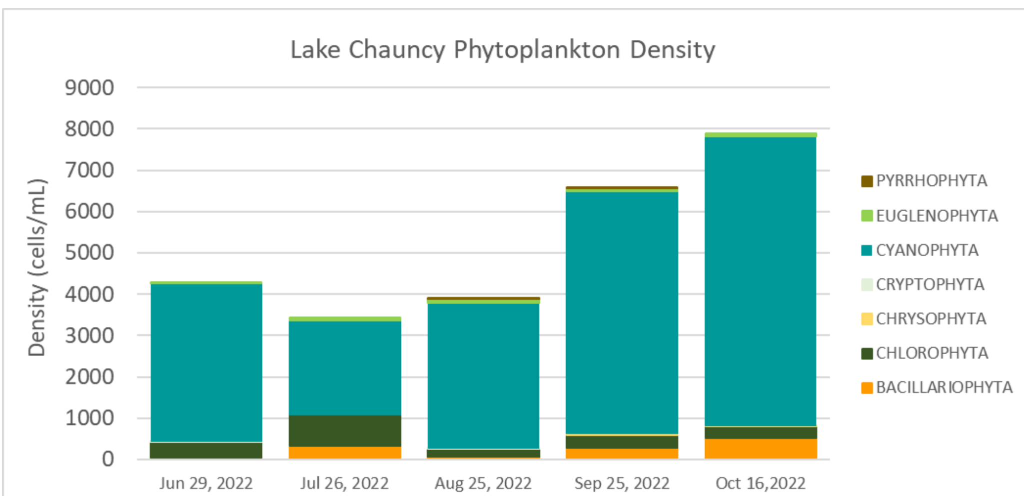


Figure 7. Phytoplankton Density in Lake Chauncy 2022

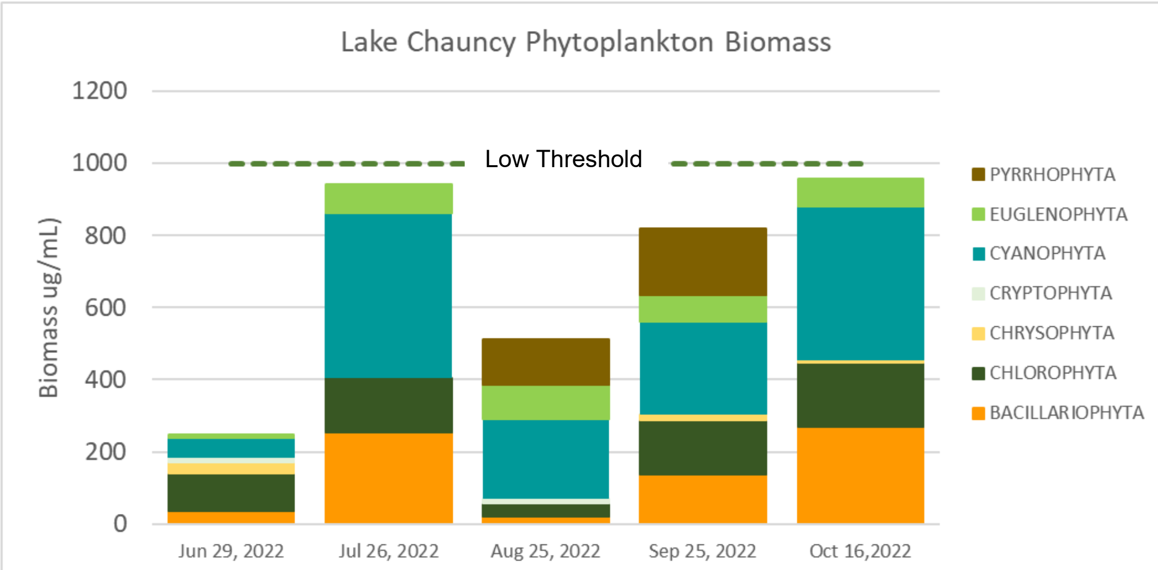


Figure 8. Phytoplankton Biomass in Lake Chauncy 2022.

Zooplankton

Zooplankton biomass was high in June and August with copepods and cladocerans dominating (Figure 9). Biomass was low in the other months. Biomass values in excess of 100 ug/L is considered high, while values <50 ug/L are low and values <10 ug/L are very low. Cladocerans are non-selective grazers but generally consume small phytoplankton whereas Copepods are thought to select for and consume larger phytoplankton. Rotifers were more prevalent in September. Given the high variability in biomass and types of zooplankton present, grazing pressure on algae is likely moderate.

The ideal mean lengths of zooplankton is between 0.4 and 0.8 mm, which indicate a balance between growth and predation, with smaller means suggesting intense predation and larger means suggesting low predation. Mean length for zooplankton in Lake Chauncy was in the ideal range in June through August but was low in the fall (Figure 10).

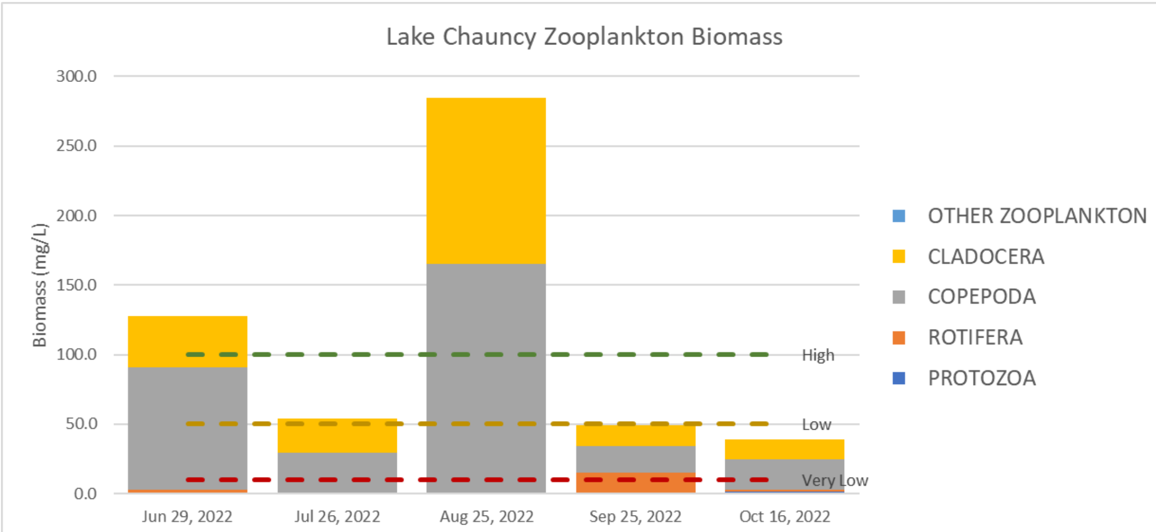


Figure 9. Lake Chauncy Zooplankton Biomass 2022.

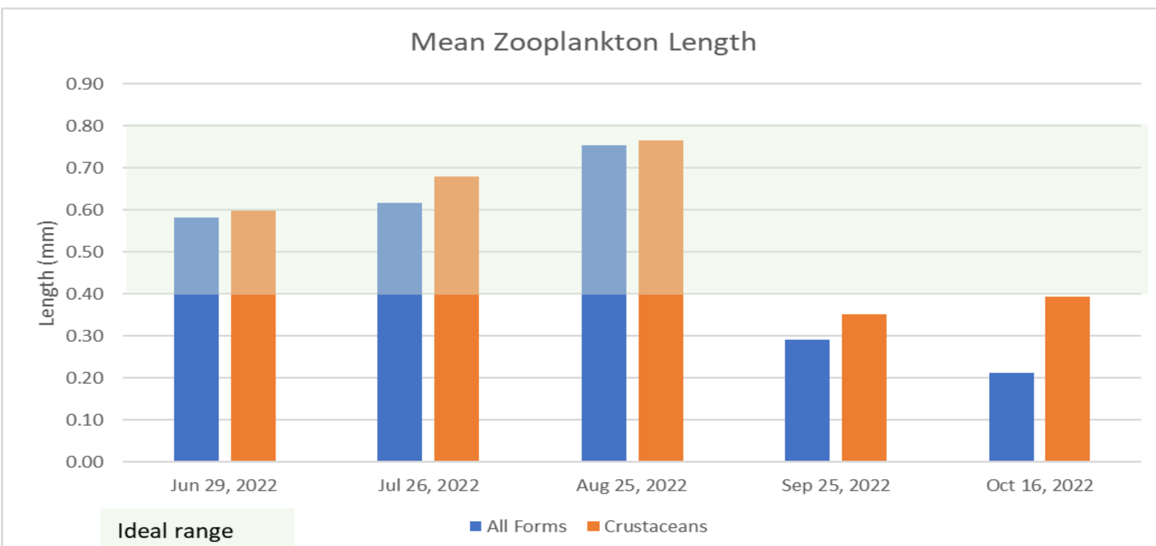


Figure 10. Lake Chauncy Mean Zooplankton Length 2022.

Lake Sediment Phosphorus and Internal Loading

Phosphorus can be released from sediments under anoxic conditions. The dissolved oxygen profiles illustrate that anoxia occurs below 12 feet. The oxygen demand is a function of decomposition in the water column and in sediments. The waters above the sediment are stripped of oxygen which is not replaced by photosynthesis or mixing with overlying oxygen rich waters. This persistent condition creates a thick anoxic layer in Lake Chauncy. Warm temperatures and longer stratification periods favor cyanobacteria (Paerl and Huisman, 2009[8]), further exasperating blooms and the internal phosphorus recycling problem.

Lake Chauncy contains moderate concentrations of phosphorus in sediment (Table 4). Average sediment TP was 1,322 milligrams per kilogram (mg/kg), twice as high as the average calculated in the Whitman & Howard report (TP 651 mg/kg). Total P is the sum of all fractions minus Biogenic P, which is part of the organic P fraction. Only a portion of organic P is released under anoxic conditions, whereas iron bound phosphorus (Fe-P) is readily released during anoxic conditions. This fraction is typically used to inform the amount of phosphorus requiring inactivation. While biogenic P can be released, it tends to occur slower than Fe-P release and is only considered if concentrations are excessive.

Much of the phosphorus in Lake Chauncy sediments is organic. Only 2-4% of the phosphorus is iron bound. However, this is enough to increase overlying water phosphorus concentrations and fuel algal blooms. If as little as 10% of the Fe-P was released, this could raise the water phosphorus concentration by five micrograms (ug) per liter (or 0.005 mg/L), driving the average water phosphorus up to 0.038 mg/L, well above the 0.025 mg/L EPA Gold Standard threshold. This does not include any of the organic P that also could also be released. If 20% of Fe-P was released, predicted concentrations would be 0.042 mg/L.

Table 4. Lake Chauncy Sediment Phosphorus Fractions

Sample ID	% Solids	% Water	Total Organic Carbon	TP (mg/kg)	Loosely Bound P (mg/kg)	Fe-P (mg/kg)	Al-P (mg/kg)	Biogenic P (mg/kg)	Ca-P (mg/kg)	Organic P (mg/kg)
CL SED-1	9.3%	90.7%	14.8%	2,011	<2.0	56.8	966	607	251	738
CL SED-1 DUPLICATE	9.3%	90.7%	15.0%	1,847	<2.0	76.8	994	349	265	510
CL SED-2	11.2%	88.8%	12.0%	1,002	<2.0	18.6	458	149	266	260
CL SED-3	11.4%	88.6%	12.5%	1,036	<2.0	20.0	503	145	221	292

8 Paerl, H.W., and Huisman, J. (2009) Climate change: a catalyst for global expansion of harmful cyanobacterial blooms. Environmental Microbiology Reports 1: 27-37.

Diagnostic Summary

Lake Chauncy has a relatively small watershed but water quality is greatly influenced by anthropogenic influences, especially in the immediate surrounding area. Even though stormwater and groundwater influences were not measured during this investigation, previous studies have concluded that phosphorus loading from these sources is excessive.

Water quality of Lake Chauncy is listed as impaired by the State of Massachusetts for non-native rooted plants and harmful algal blooms. Excessive nutrients (nitrogen and phosphorus) are the root cause of algal blooms. The lake also experiences less than desirable water clarity at times. Oxygen below 12 feet is nonexistent. These anoxic conditions support the release of phosphorus from sediments increasing the availability of nutrients for algal blooms. There is no significant flushing of the lake to counter act (dilute) the internal recycling of nutrients. While occasional storms add surface water from the watershed and some groundwater, Whitman & Howard's data suggest that these sources contain elevated nutrients and would only exacerbate the phosphorus conditions. In-lake phosphorus is enough to support algal blooms and the constant source of phosphorus provided by sediments is likely a contributor during the dry summer months, but the watershed and groundwater studies need to be repeated to update the watershed contribution and develop a total nutrient budget of the lake.

Previous surveys suggest the lake has a diverse plant community, but the community includes several non-native invasive species (Eurasian watermilfoil, curly leaf pondweed, fanwort and possibly others). Plant biomass can be dense, and decay of plant material will also contribute to the biological oxygen demand and the phosphorus load. Phosphorus will continue to accumulate in lake sediments from the breakdown of organic material and will remove oxygen from the water during this process. Applying herbicides to control rooted plant growth is an acceptable measure when appropriate, but it will not remove existing plant biomass from the lake. It will prevent additional growth later in the season, however.

The phytoplankton biomass was low in 2022, although wind/wave concentrated scums were present during site visits. The low numbers may be the result of repeated algicide treatments in recent years. The predominant number of phytoplankton cells in samples during 2022 are from known toxin producing cyanobacteria (primarily *Microcystis* and *Dolichospermum*). Cyanobacteria blooms were problematic in 2011, 2016 and 2019. Since this time, SOLitude, a licensed herbicide/algicide application contractor, monitors the lake throughout the summer to measure and identify phytoplankton. SOLitude applies copper sulfate on an as needed basis to prevent blooms.

While phycologists have a good understanding of which cyanobacteria produce toxins, they cannot predict when the do. Cyanobacteria could produce toxins as a competitive advantage against other algal cells competing for the same resources, like nutrients and sunlight. They also could produce toxins during times of stress (unfavorable conditions) or some other scenario scientists haven't identified. Interestingly, some noxious blooms may not produce toxins in concentrations high enough to cause health issue for humans, pets, or wildlife, while other blooms that appear less severe (less of a scum, lower cell counts) can pose a significant risk. For these reasons we recommend posting advisories to stay out of the water and prevent pets from swimming and drinking the water when a scum is present. Several dogs were observed swimming and drinking directly in the bloom at the State-owned boat launch in 2022. There is no signage at the information kiosk at the launch warning pet owners of the danger to their dogs, which can be severe enough to cause death. The Town should work with the State to acquire signage warning pet owners to forbid their dogs from swimming and drinking when a scum is present.

The zooplankton community (both in density and size) is variable, with some months exhibiting a desirable community that can graze well on the phytoplankton reducing algae biomass. However, other months have very low zooplankton numbers and would not have a measurable impact on the phytoplankton. It is not known what is causing this variability; it could be predation by fish or low phytoplankton numbers associated with algaecide treatments or fluctuating phosphorus availability.

Internal loading of phosphorus is occurring and could be a significant component of the overall nutrient budget but knowledge of the watershed contribution (groundwater and stormwater) is needed before the proportion of the total load to the lake can be determined. There are lake management measures such as phosphorus inactivation and aeration/oxygenation that may help alleviate the impact of this source, however the success of both techniques will depend on careful planning and design. Neither technique is inexpensive nor will have lasting effects if the watershed is found to contribute significantly to the lake nutrient load. Phosphorus inactivation with alum (aluminum sulfate) will cost approximately $230,000 but could provide 15 to 20 years of control if phosphorus inputs from the watershed (storm and ground water) are controlled. Oxygenation costs are not as straightforward because the system requires site work, electricity, annual supplies and maintenance. The upfront cost may be comparable to alum but maintenance, supplies and electricity costs could exceed $10,000 annually. If the Town is interested in pursuing this technique, it is recommended that they contact an aeration/oxygenation contractor that can price this service for you.

Recommendations

- Continue monthly water quality monitoring. Consider monthly sampling from May-September. Monitoring should include temperature and DO water depth profiles, pH, conductivity and turbidity. Sampling should include grab samples at the surface and bottom for nutrients (TP, TKN, NO_2+NO_3, and NH_3). Continue monthly grab sampling of phytoplankton and tows to obtain zooplankton samples.
- Continue the algal monitoring and copper sulfate treatments as needed – health and safety of the public is paramount; preventing blooms, closures and advisories should continue. Consider acquiring a fluorometer that Board of Health members can use to monitor between contractor visits/sampling. Consider posting warnings even in times when blooms are not occurring recommending avoiding contact with the water (including pet contact) when visible scums are present and alert users of possible risks.
- Perform watershed and groundwater monitoring to update data collected by Whitman & Howard in 1984-1985. Include paired dry and wet weather watershed sampling.
- Generate a total annual phosphorus and nitrogen loading budget from data provided in this report and data acquired from the updated watershed/groundwater study as suggested above.
- Explore feasibility of management measures to reduce internal and external phosphorus loading based on identified sources.
- The Town should continue to apply for grants to help fund monitoring and potential nutrient reduction measures (watershed controls, in-lake phosphorus inactivation, aeration, etc.).
- Perform annual plant monitoring to assess plant community diversity and potential expansion of non-natives.
- Consider additional plant control methodologies in addition to herbicides as applicable.
- Continue to educate the community regarding the cause of cyanobacteria blooms, importance of nutrient reduction and avoidance of non-native plant species introduction.

Appendix – A
Plankton Data

	PHYTOPLANKTON DENSITY (CELLS/ML)					PHYTOPLANKTON BIOMASS (UG/L)				
	CL-1s	CL-1s	CL-1s	CL-1s	CL-1s	CL-1s	CL-1s	CL-1s	CL-1s	CL-1s
TAXON	06/29/22	07/26/22	08/25/22	09/25/22	10/16/22	06/29/22	07/26/22	08/25/22	09/25/22	10/16/22
BACILLARIOPHYTA										
Centric Diatoms										
Acanthoceras	0	0	0	21	76	0.0	0.0	0.0	25.2	91.2
Aulacoseira	0	0	65	63	61	0.0	0.0	19.4	18.9	18.2
Urosolenia	0	0	0	11	61	0.0	0.0	0.0	12.6	73.0
Araphid Pennate Diatoms										
Asterionella	9	0	0	11	76	1.7	0.0	0.0	2.1	15.2
Fragilaria/related taxa	0	23	0	126	243	0.0	6.8	0.0	37.8	73.0
Synedra	9	11	0	21	0	6.8	9.1	0.0	16.8	0.0
Tabellaria	34	296	0	32	0	27.2	237.1	0.0	25.2	0.0
Monoraphid Pennate Diatoms										
Biraphid Pennate Diatoms										
CHLOROPHYTA										
Flagellated Chlorophytes										
Coccoid/Colonial Chlorophytes										
Coelastrum	0	137	0	0	0	0.0	27.4	0.0	0.0	0.0
Elakatothrix	17	23	43	42	30	1.7	2.3	5.8	6.3	6.1
Kirchneriella	0	0	29	0	0	0.0	0.0	2.9	0.0	0.0
Oocystis	17	46	29	0	0	6.8	18.2	11.5	0.0	0.0
Pediastrum	0	0	29	126	152	0.0	0.0	5.8	25.2	30.4
Quadrigula	34	46	0	0	0	6.8	9.1	0.0	0.0	0.0
Scenedesmus	0	46	58	84	61	0.0	4.6	5.8	8.4	6.1
Schroederia	9	0	0	0	0	21.3	0.0	0.0	0.0	0.0
Sphaerocystis	272	456	0	0	0	54.4	91.2	0.0	0.0	0.0
Filamentous Chlorophytes										
Desmids										
Closterium	0	0	0	21	30	0.0	0.0	0.0	84.0	121.6
Staurastrum	17	0	7	32	15	13.6	0.0	5.8	25.2	12.2
CHRYSOPHYTA										
Flagellated Classic Chrysophytes										
Dinobryon	9	0	0	0	0	25.5	0.0	0.0	0.0	0.0
Mallomonas	9	0	0	32	15	4.3	0.0	0.0	15.8	7.6
Non-Motile Classic Chrysophytes										
Haptophytes										
Tribophytes/Eustigmatophytes										
Raphidophytes										
CRYPTOPHYTA										
Cryptomonas	9	0	14	0	0	13.6	0.0	13.0	0.0	0.0
CYANOPHYTA										
Unicellular and Colonial Forms										
Aphanocapsa	0	0	0	630	0	0.0	0.0	0.0	6.3	0.0
Gomphosphaeria	3740	0	288	0	0	37.4	0.0	2.9	0.0	0.0
Microcystis	0	0	2520	4200	4560	0.0	0.0	75.6	42.0	45.6
Filamentous Nitrogen Fixers										
Aphanizomenon	0	0	0	0	1520	0.0	0.0	0.0	0.0	197.6
Dolichospermum	85	2280	720	1050	912	17.0	456.0	144.0	210.0	182.4
Filamentous Non-Nitrogen Fixers										
EUGLENOPHYTA										
Trachelomonas	9	80	94	74	76	8.5	79.8	93.6	73.5	76.0
PYRRHOPHYTA										
Ceratium	0	0	7	11	0	0.0	0.0	125.3	182.7	0.0

DENSITY (CELLS/ML) SUMMARY											
BACILLARIOPHYTA	51	330.6	64.8	283.5	516.8		35.7	253.1	19.4	138.6	270.6
Centric Diatoms	0	0	64.8	94.5	197.6		0.0	0.0	19.4	56.7	182.4
Araphid Pennate Diatoms	51	330.6	0	189	319.2		35.7	253.1	0.0	81.9	88.2
Monoraphid Pennate Diatoms	0	0	0	0	0		0.0	0.0	0.0	0.0	0.0
Biraphid Pennate Diatoms	0	0	0	0	0		0.0	0.0	0.0	0.0	0.0
CHLOROPHYTA	365.5	752.4	194.4	304.5	288.8		104.6	152.8	37.4	149.1	176.3
Flagellated Chlorophytes	0	0	0	0	0		0.0	0.0	0.0	0.0	0.0
Coccoid/Colonial Chlorophytes	348.5	752.4	187.2	252	243.2		91.0	152.8	31.7	39.9	42.6
Filamentous Chlorophytes	0	0	0	0	0		0.0	0.0	0.0	0.0	0.0
Desmids	17	0	7.2	52.5	45.6		13.6	0.0	5.8	109.2	133.8
CHRYSOPHYTA	17	0	0	31.5	15.2		29.8	0.0	0.0	15.8	7.6
Flagellated Classic Chrysophytes	17	0	0	31.5	15.2		29.8	0.0	0.0	15.8	7.6
Non-Motile Classic Chrysophytes	0	0	0	0	0		0.0	0.0	0.0	0.0	0.0
Haptophytes	0	0	0	0	0		0.0	0.0	0.0	0.0	0.0
Tribophytes/Eustigmatophytes	0	0	0	0	0		0.0	0.0	0.0	0.0	0.0
Raphidophytes	0	0	0	0	0		0.0	0.0	0.0	0.0	0.0
CRYPTOPHYTA	8.5	0	14.4	0	0		13.6	0.0	13.0	0.0	0.0
CYANOPHYTA	3825	2280	3528	5880	6992		54.4	456.0	222.5	258.3	425.6
Unicellular and Colonial Forms	3740	0	2808	4830	4560		37.4	0.0	78.5	48.3	45.6
Filamentous Nitrogen Fixers	85	2280	720	1050	2432		17.0	456.0	144.0	210.0	380.0
Filamentous Non-Nitrogen Fixers	0	0	0	0	0		0.0	0.0	0.0	0.0	0.0
EUGLENOPHYTA	8.5	79.8	93.6	73.5	76		8.5	79.8	93.6	73.5	76.0
PYRRHOPHYTA	0	0	7.2	10.5	0		0.0	0.0	125.3	182.7	0.0
TOTAL	4275.5	3442.8	3902.4	6583.5	7888.8		246.5	941.6	511.2	818.0	956.1
CELL DIVERSITY	0.26	0.53	0.52	0.56	0.60		1.03	0.64	0.81	1.00	0.99
CELL EVENNESS	0.22	0.51	0.47	0.45	0.51		0.87	0.62	0.72	0.80	0.84
NUMBER OF TAXA											
BACILLARIOPHYTA	3	3	1	7	5						
Centric Diatoms	0	0	1	3	3						
Araphid Pennate Diatoms	3	3	0	4	2		6/29/22	7/26/22	8/25/22	9/25/22	10/16/22
Monoraphid Pennate Diatoms	0	0	0	0	0						
Biraphid Pennate Diatoms	0	0	0	0	0		36	253	19	139	271
CHLOROPHYTA	6	6	6	5	5		105	153	37	149	176
Flagellated Chlorophytes	0	0	0	0	0		30	0	0	16	8
Coccoid/Colonial Chlorophytes	5	6	5	3	3		14	0	13	0	0
Filamentous Chlorophytes	0	0	0	0	0		54	456	222	258	426
Desmids	1	0	1	2	2		9	80	94	74	76
CHRYSOPHYTA	2	0	0	1	1		0	0	125	183	0
Flagellated Classic Chrysophytes	2	0	0	1	1						
Non-Motile Classic Chrysophytes	0	0	0	0	0						
Haptophytes	0	0	0	0	0						
Tribophytes/Eustigmatophytes	0	0	0	0	0						
Raphidophytes	0	0	0	0	0						
CRYPTOPHYTA	1	0	1	0	0						
CYANOPHYTA	2	1	3	3	3						
Unicellular and Colonial Forms	1	0	2	2	1						
Filamentous Nitrogen Fixers	1	1	1	1	2						
Filamentous Non-Nitrogen Fixers	0	0	0	0	0						
EUGLENOPHYTA	1	1	1	1	1						
PYRRHOPHYTA	0	0	1	1	0						
TOTAL	15	11	13	18	15						

TAXON	ZOOPLANKTON DENSITY (#/L)					ZOOPLANKTON BIOMASS (UG/L)				
	CL-1s 6/29/22	CL-1s 7/26/22	CL-1s 8/25/22	CL-1s 9/25/22	CL-1s 10/16/22	CL-1s 6/29/22	CL-1s 7/26/22	CL-1s 8/25/22	CL-1s 9/25/22	CL-1s 10/16/22
PROTOZOA										
Ciliophora	0.0	0.0	0.0	0.0	18.3	0.0	0.0	0.0	0.0	1.2
Mastigophora	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sarcodina	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ROTIFERA										
Asplanchna	1.3	0.4	0.0	6.6	0.0	2.6	0.8	0.0	14.4	0.0
Conochilus	0.0	0.0	0.0	0.8	1.6	0.0	0.0	0.0	0.0	0.1
Filinia	0.0	0.0	0.7	1.2	0.0	0.0	0.0	0.1	0.0	0.0
Hexarthra	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Kellicottia	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Keratella	0.0	0.0	0.0	4.7	8.6	0.0	0.0	0.0	0.4	0.8
Polyarthra	0.0	0.4	0.0	3.9	5.5	0.0	0.1	0.0	0.4	0.5
Trichocerca	1.3	0.8	0.7	1.6	0.8	0.1	0.0	0.0	0.1	0.0
COPEPODA										
Copepoda-Cyclopoida										
Cyclops	1.0	1.2	2.6	0.0	2.0	2.3	2.9	13.8	0.0	4.8
Mesocyclops	2.2	0.4	15.2	0.0	1.2	7.3	0.5	112.5	0.0	1.5
Copepoda-Calanoida										
Diaptomus	16.6	5.5	5.3	0.8	2.3	54.6	11.4	19.5	0.4	1.1
Other Copepoda-Nauplii	9.0	5.1	7.3	7.0	5.5	23.7	13.4	19.2	18.6	14.5
CLADOCERA										
Bosmina	9.6	0.0	5.3	7.0	12.5	10.7	0.0	5.2	6.9	12.2
Ceriodaphnia	1.0	0.8	0.7	1.6	0.0	3.9	5.4	4.5	7.4	0.0
Chydorus	2.2	1.6	7.9	0.4	0.0	2.2	1.5	15.7	0.4	0.0
Daphnia dubia	2.2	0.4	0.7	0.0	0.4	18.7	4.3	7.3	0.0	2.5
Diaphanosoma	0.6	4.3	28.4	0.0	0.0	1.3	13.8	86.5	0.0	0.0
OTHER ZOOPLANKTON										
SUMMARY STATISTICS										
DENSITY										
PROTOZOA	0.0	0.0	0.0	0.0	18.3	0.0	0.0	0.0	0.0	1.2
ROTIFERA	2.6	2.7	1.3	18.7	16.4	2.6	1.0	0.1	15.3	1.4
COPEPODA	28.8	12.1	30.4	7.8	10.9	88.0	28.2	165.1	19.0	21.8
CLADOCERA	15.7	7.0	42.9	9.0	12.9	36.7	25.0	119.1	14.7	14.7
OTHER ZOOPLANKTON	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL ZOOPLANKTON	47.0	21.8	74.6	35.5	58.5	127.3	54.2	284.4	49.0	39.1
TAXONOMIC RICHNESS										
PROTOZOA	0	0	0	0	1					
ROTIFERA	2	5	2	6	4					
COPEPODA	4	4	4	2	4					
CLADOCERA	5	4	5	3	2					
OTHER ZOOPLANKTON	0	0	0	0	0					
TOTAL ZOOPLANKTON	11	13	11	11	11					
S-W DIVERSITY INDEX	0.81	0.90	0.79	0.90	0.84					
EVENNESS INDEX	0.77	0.81	0.76	0.86	0.80					
MEAN LENGTH (mm): ALL FORMS	0.58	0.62	0.75	0.29	0.21					
MEAN LENGTH: CRUSTACEANS	0.60	0.68	0.76	0.35	0.39					